AN ATLAS OF BATHY-THERMOGRAPH TEMPERATURE CROSS-SECTIONS FOR CORAL AND TASMAN SEA TRANSECTS FROM 1960 TO 1987

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L.J. HAMILTON

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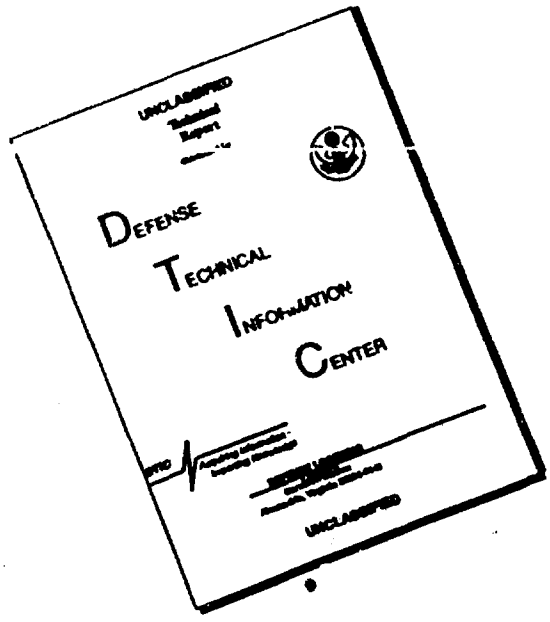

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An Atlas of Bathy-Thermograph Temperature Cross-Sections for Coral and Tasman Sea Transects from 1960 to 1987

L.J. Hamilton

MRL Technical Note
MRL-TN-620

Abstract

An atlas of 190 temperature cross-sections is presented for the Tasman and Coral Seas for 1960 to 1987. The sections were constructed from bathy-thermograph (BT) temperature profiles obtained by ships on routes between Australia, New Zealand, and Fiji in the region 20-50 S, 150-180 E. About 150 sections lie on six major routes, e.g. 50 sections are available from Sydney to New Zealand along 34 S, and 40 sections from Sydney to Fiji. Depth of sections is nominally 450 m. The sections provide the background for an examination of Tasman and Coral Sea surface flow and temperature structure presented elsewhere. Data were obtained from the Australian Oceanographic Data Centre.

DEPARTMENT OF DEFENCE
DSTO MATERIALS RESEARCH LABORATORY

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DSTO Materials Research Laboratory
Cordite Avenue, Maribyrnong
Victoria, 3032 Australia

Telephone: (03) 246 8111
Fax: (03) 246 8999

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An Atlas of Bathy-Thermograph Temperature Cross-Sections for Coral and Tasman Sea Transects from 1960 to 1987

1. Introduction

Naval and oceanographic vessels regularly obtain oceanographic temperature profiles when transiting the world's seas. The temperature/depth data are obtained by a bathy-thermograph instrument system, which consists of an expendable thermistor probe assembly connected by thin conducting wire to an analogue or digital recording system. The probe is dropped overboard while the ship is underway or stationary, and feeds back temperature information while free falling until the wire breaks, usually at a probe depth of about 500 m. The temperature information is used for sonar range predictions, and for oceanographic and meteorological applications such as the detection of oceanic fronts and currents. Data bases of bathy-thermograph data are kept by various world oceanographic data centres.

Examination of bathy-thermograph (BT) data held by the Australian Oceanographic Data Centre, North Sydney has shown the presence of about two hundred transects between Australia, New Zealand, and Fiji. Ship track and temperature cross section are compiled herein for some 190 such transects. The transects tend to lie on particular shipping routes, e.g. from Sydney to the northern tip of New Zealand (see Fig. 1 and Table 1).

Such large numbers of basin wide transects form a potential data base of great usefulness to oceanographers, but their existence has apparently been unknown, with only a handful used in scientific analyses. Only very broad oceanographic details are known for most parts of the Coral and Tasman Seas. The concentration of ship tracks along particular routes could enhance the present knowledge of these areas through the construction of various climatologies by statistical methods. It is possible, for example, to calculate approximations to geostrophic current profiles perpendicular to BT pairs by coupling the temperature profiles with synthesised salinity profiles. Climatologies of surface currents, associated subsurface temperature structure, and surface mixed layer depths could be constructed for the particular routes of Figure 1.

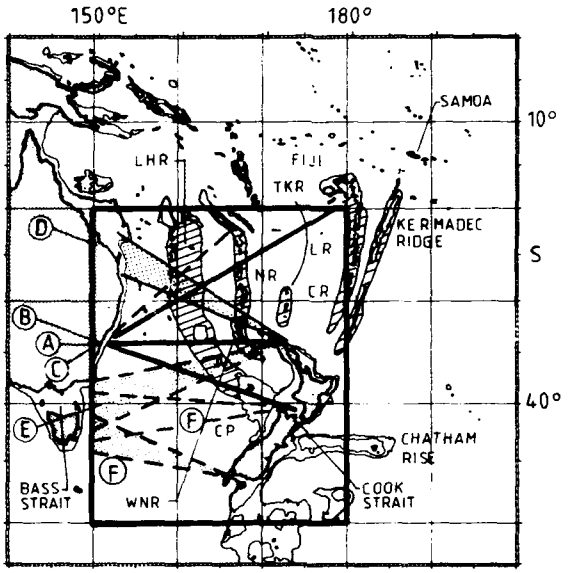

Figure 1: *Basin wide routes A to F in the Coral and Tasman Seas for which repeated expendable bathy-thermograph temperature sections are available. See Table 1 for seasonal numbers. Stippling indicates that transects are not concentrated on a particular route. The contour is for 1000 m, with hatched areas indicating the general position of ridges and rises, but not an actual depth contour. Dashed transects have only 7 to 12 XBT sections. Route F consists of sets of near zonal transects between Tasmania and New Zealand.*

CP - Challenger Plateau
CR - Colville Ridge
LHR - Lord Howe Rise
LR - Lau Ridge
NR - Norfolk Ridge
TKR - Three Kings Ridge
WNR - West Norfolk Ridge

Table 1: Numbers of XBT sections by season for the five principal routes of Figure 1, and time spans for the sections.

A - Sydney to New Zealand along 34 S;
B - Sydney to Cook Strait;
C - Sydney to south of Fiji;
D - Central Queensland to north New Zealand;
E - Tasmania to north of New Zealand.

Summer (Jan-Feb-March), Autumn (April-May-June),
Winter (July-Aug-September), Spring (Oct-Nov-December).

Route:	A	B	C	D	E
Years:	1960-91	1967-87	1968-87	1970-80	1973-82
Summer:	14	7	5	3	1
Autumn:	6	3	14	1	2
Winter:	13	6	9	4	1
Spring:	17	7	11	4	4
Total:	50	23	39	12	8

Results from such an analysis are to be found in Hamilton [1]. It is shown in [1] that the mesoscale circulation from Sydney to New Zealand along 34 S is seasonal, and is strongly influenced by the topography of seamount chains, ridges, and rises. The BT temperature sections in the present document are provided as the background for that analysis, and as a stand alone data set for use by others.

2. *Data and Methods*

A magnetic tape of bathy-thermograph (BT) data was obtained from the Australian Oceanographic Data Centre (AODC) on 27 April 1990 for the area 20-50 S, 140-180 E. The tape contained no data after 1987, but not all data to that date were included in the data base. BT positions were plotted showing AODC cruise number to show up basin wide transects in the Tasman and Coral Seas.

Temperature cross-sections were computer constructed for transects having BT spacing less than about three and a half degrees of longitude (325 km at 34 S). BT positions were projected onto a straight line joining two points on a Mercator projection of reference latitude 27 15'S. The AODC BT data are stored as break points (inflexion points in the vertical temperature profile). To get reliable automatic contouring by computer algorithms the break points were converted to fixed depth (10 m) interpolations in the vertical. Without this procedure mixed layers and widely separated vertical break points can cause poor contouring, since the vertical connectedness of points is unknown to the contouring routines. De Launay triangulation contouring as instituted by Watson [2] was used to contour the interpolations. This method produces contours close to those drawn manually. Fault planes for land boundaries or topographic features were not

used. Contours towards the lower limits of sections are therefore occasionally spurious where BTs attain different depths, and BTs much shallower than adjacent BTs must also sometimes be allowed for.

The BT data are mostly for expendable bathy-thermographs (XBTs). A small number of mechanical bathy-thermograph (MBT) sections are included, but these are usually rather shallow, sometimes less than 100 m deep, whereas the XBT sections usually reach 450 m.

The ship tracks and temperature sections presented are only a subset of the total number which could have been constructed from the data. For the most part sections were constructed only if the track spanned the width of the Coral/Tasman Seas between Australia and New Zealand, or Australia and Fiji, and then only if BT spacing was less than 3 to 4 degrees or so of longitude. Mesoscale features are unresolved by wider spacing, although such sections can be useful for broader studies. Extensions of sections outside the study area were also neglected. Many other long sections could be constructed for tracks along the Australian coastline, particularly from Sydney to the north. Sections east of New Zealand were also ignored, except for a few southeast of South Island, where more are available. Some short sections are provided herein, for data sparse areas and for closely spaced BT, but most short sections were ignored. There are large numbers of possible short sections in some areas, e.g. near Sydney. As an example Boland [3, 4] analysed six years of BT sections obtained at fortnightly intervals for July 1969 to July 1975 from Sydney to 156 E along 34 S, with some sections out to 160 and 164 E. These data were from the CSIRO data banks however, not those of the AODC.

3. *Data Presentation*

The transects tend to lie on definite routes (Fig. 1) which run in crossing directions to give full area coverage between Australia and New Zealand. Sections are therefore grouped by route and are ordered for each route by AODC cruise number, regardless of date or season, to enable cross-referencing back to the AODC data bank. Bottom topography for the study area is shown in Figure 2, and the routes A-F of Figure 1 are shown at the same scale as the topography in Figure 3.

The routes (labelled A to G) are as follows:

(A) Sydney to the northern tip of New Zealand along 34 S (50 sections);
(B) Sydney to Cook Strait, New Zealand (23 sections);
(C) Sydney to south of Fiji (and Vanuatu) (39 sections);
(D) Central Queensland to the northern tip of New Zealand (12 sections);
(E) Tasmania to north of New Zealand (8 sections);
(F) Zonal transects from Tasmania to New Zealand (18 sections);
(G) Miscellaneous transects (over 40 sections), including
    Hobart to south of Fiji (2)
    north New Zealand to south of Fiji (6)
    Sydney to north of New Zealand (3)
    Sydney to south of New Zealand (4)

Overplots of ship tracks for routes A to F are shown in Figures 4 to 9, with miscellaneous transects shown in Figure 10. Tables 2 to 7 for routes A to F and Table 8 for the miscellaneous transects show month and year of the sections. The temperature sections listed in Tables 2 to 8 are given on the microfiche cards included with this report, with the track for each section also shown. See Hamilton [1] for summer and winter overplots of the 15 C isotherm for some routes, and seasonal temperature, mixed layer depth, surface current and other statistics.

4. *Additional Data*

As mentioned earlier Boland [3, 4] discusses shorter sections out from Sydney along 34 S, and shows several examples. Ten MBT and XBT sections across Lord Howe Rise are shown by Denham and Crook [5], three of which are not reproduced in this atlas. Denham *et al.* [6] discusses five sections between New Zealand and Fiji for March 1976 to July 1978, all included in this atlas. Greig *et al.* [7] shows 12 sections for the northwest Coral and Bismarck Seas for June 1983 to July 1984. Roemmich and Cornuelle [8] show seventeen sections from New Zealand to Fiji for March 1986 to April 1990 in a discussion on the South Pacific gyre.

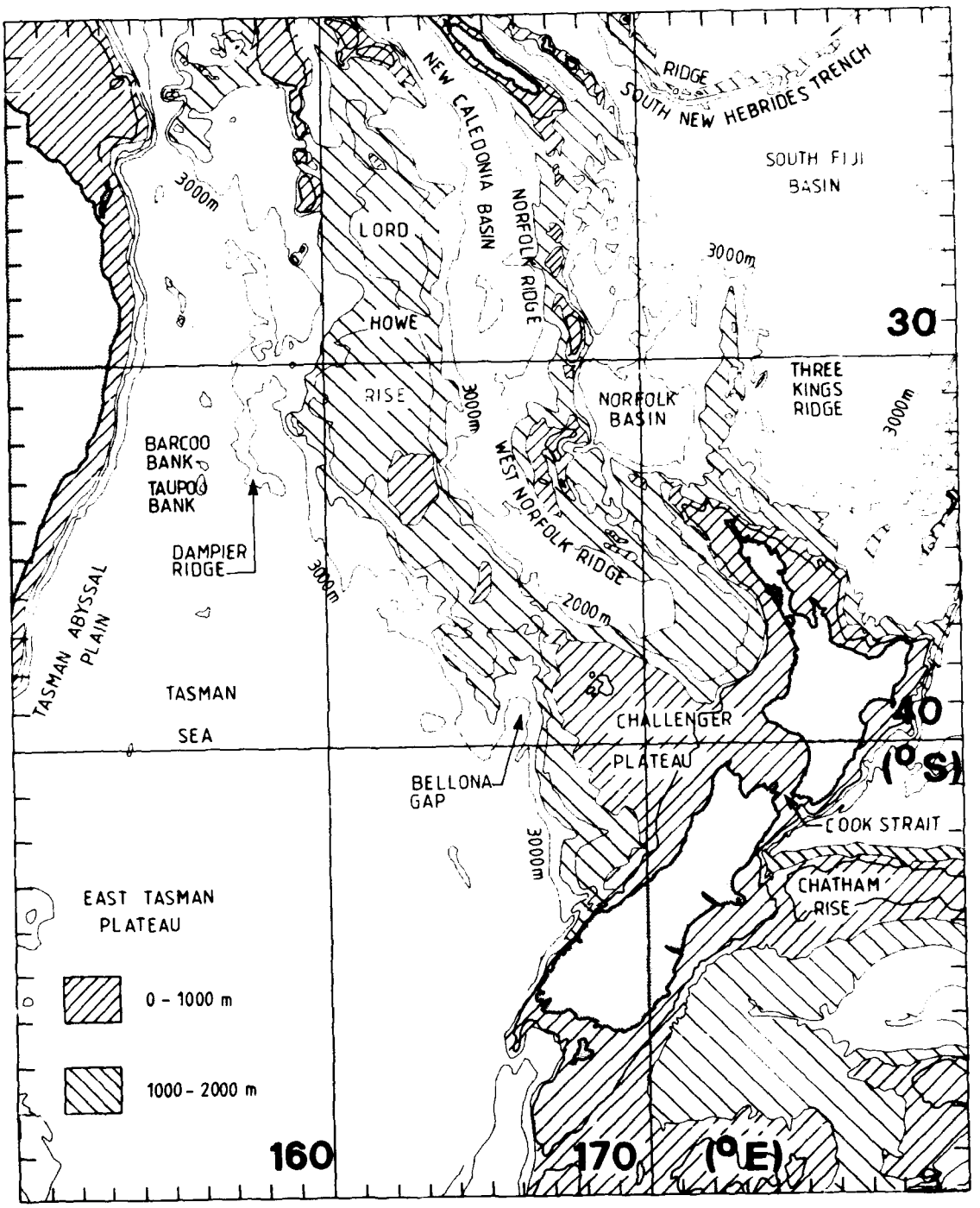

Figure 2: Bottom topography for 20-50 S, 150-180 E. From the General Bathymetric Chart of the Oceans (GEBCO) 5-10, International Hydrographic Organization, 5th edition 1982.

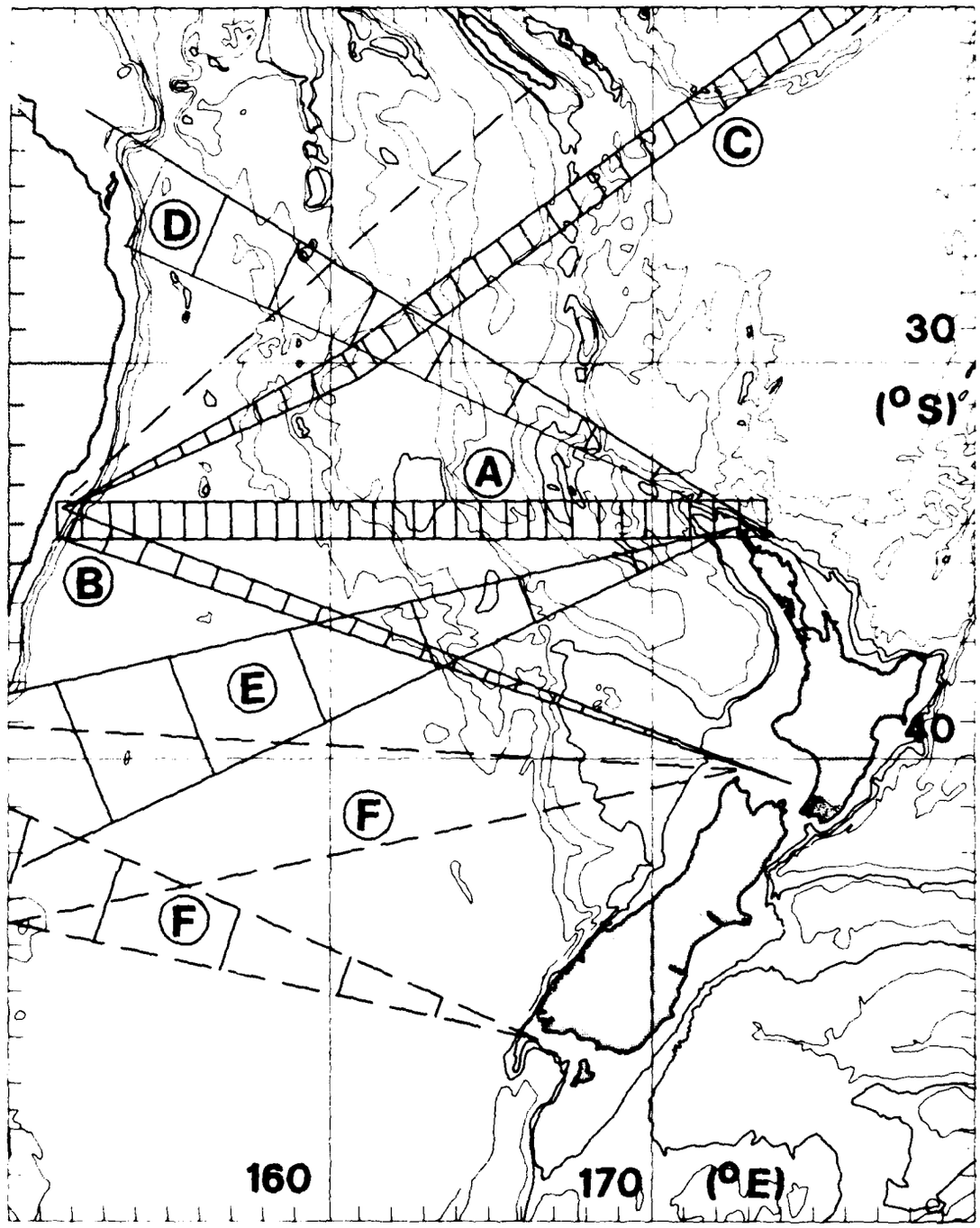

Figure 3: Routes A-F of Figure 1 superimposed on bottom topography.

Table 2: AODC cruise numbers, dates and times for BT sections from Sydney to New Zealand along 34 S (50 sections). Overplots of the ship tracks are shown in Figure 4

Survey	Month	Year	
41125	09	1967	
41469	01	1971	
42190	10	1970	
42406	02-04	1972	
42443	03	1972	
43403	11-12	1972	
43403	11-12	1972	
43960	11-12	1972	
43960	11-12	1972	
44434	01	1969	
44543	07	1972	
44797	02	1974	
44799	03	1974	
44822	01-03	1973	
44876	08-10	1973	
45177	09-10	1973	
47850	10	1971	
50271	08	1976	
50292	09-10	1975	
50320	11	1975	
51316	05	1976	
51318	06-07	1976	
52730	10-12	1977	
52730	10-12	1977	
60029	02-04	1978	
60034	10	1978	
60034	10	1978	
60044	12	1978	
60073	07-09	1979	
60076	08-10	1979	
60132	11	1980	
60224	01	1983	
60349	03	1982	
60918	04	1972	
60922	02	1972	
60925	11	1971	
60930	08	1971	
60958	03	1970	
65949	04	1981	
66151	08	1984	
66163	11-12	1984	
68237	10	1985	
68243	07	1986	
68312	10	1985	
68383	01	1982	
73545	05	1987	
G1/60	02	1960	Nansen data from R.V. Gascoyne
Cook	07	1983	Track only, XBT section not shown
Torrens	06	1988	[Constructed from telex data,
Perth	09	1991	not from original traces.]

5. Explanation of Symbols Used on the Ship Tracks and Temperature Sections

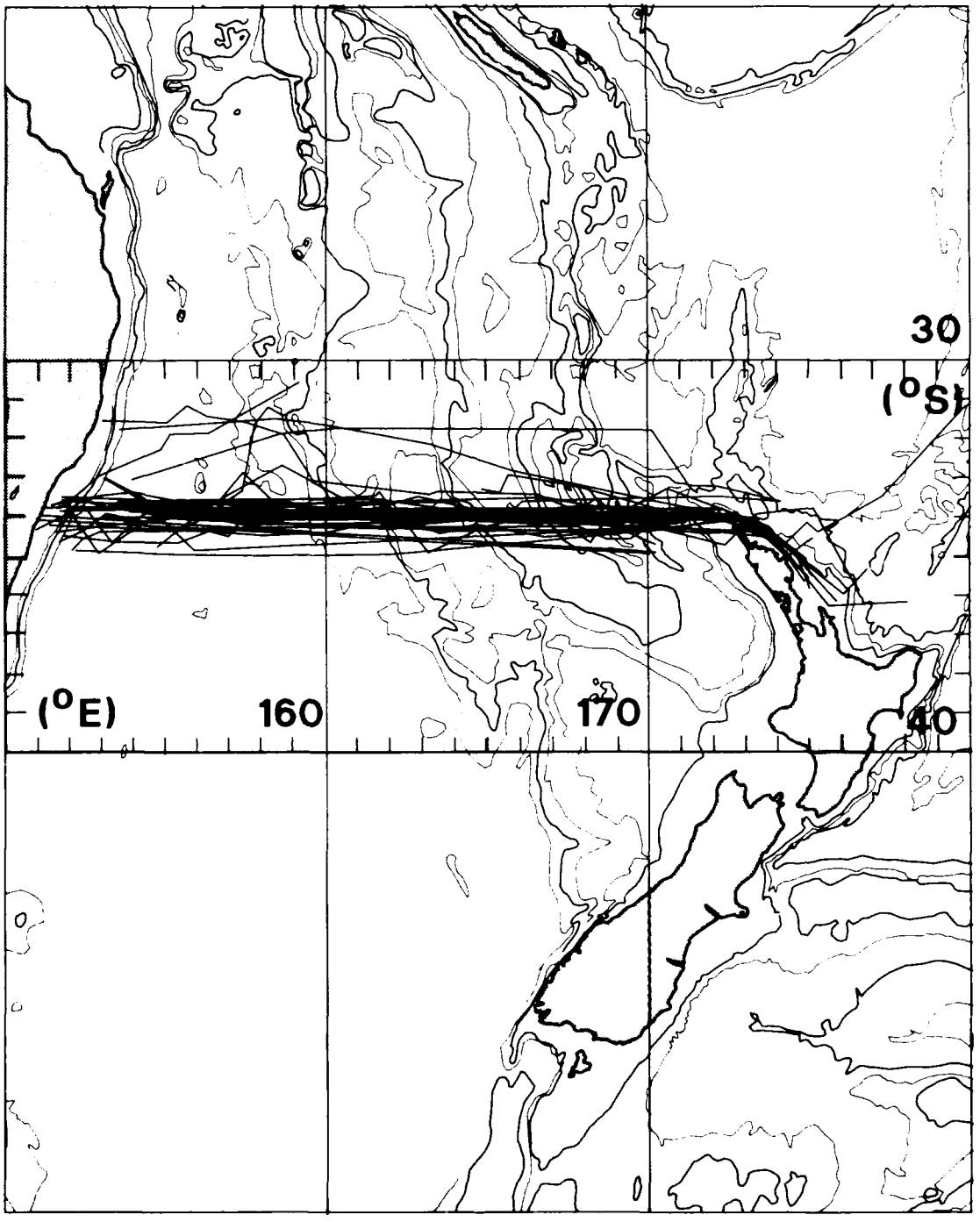

Figure 4: Overplots of 50 XBT transects along 34 S from Sydney (34 S, 151 E) to the northern tip of New Zealand (route A).

Table 3: AODC cruise numbers, dates and times for BT sections from Sydney to Cook Strait, New Zealand (23 sections). Overplots of the ship tracks are shown in Figure 5

Survey	Month	Year
41097	01	1969
42206	04	1970
42447	03	1972
43095	01-02	1972
44443	11	1968
45321	05-09	1973
46072	03	1973
46716	09	1973
47158	09-10	1970
48929	11-12	1971
48929	11-12	1971
50093	11	1975
50093	11	1975
50271	08	1976
50294	11	1975
50320	11-12	1975
50753	02-03	1976
60151	04-05	1981
60931	07	1971
68384	03-04	1982
SEAMAP 4	08	1986
SEAMAP 4	09	1986
SEAMAP 5	02	1987

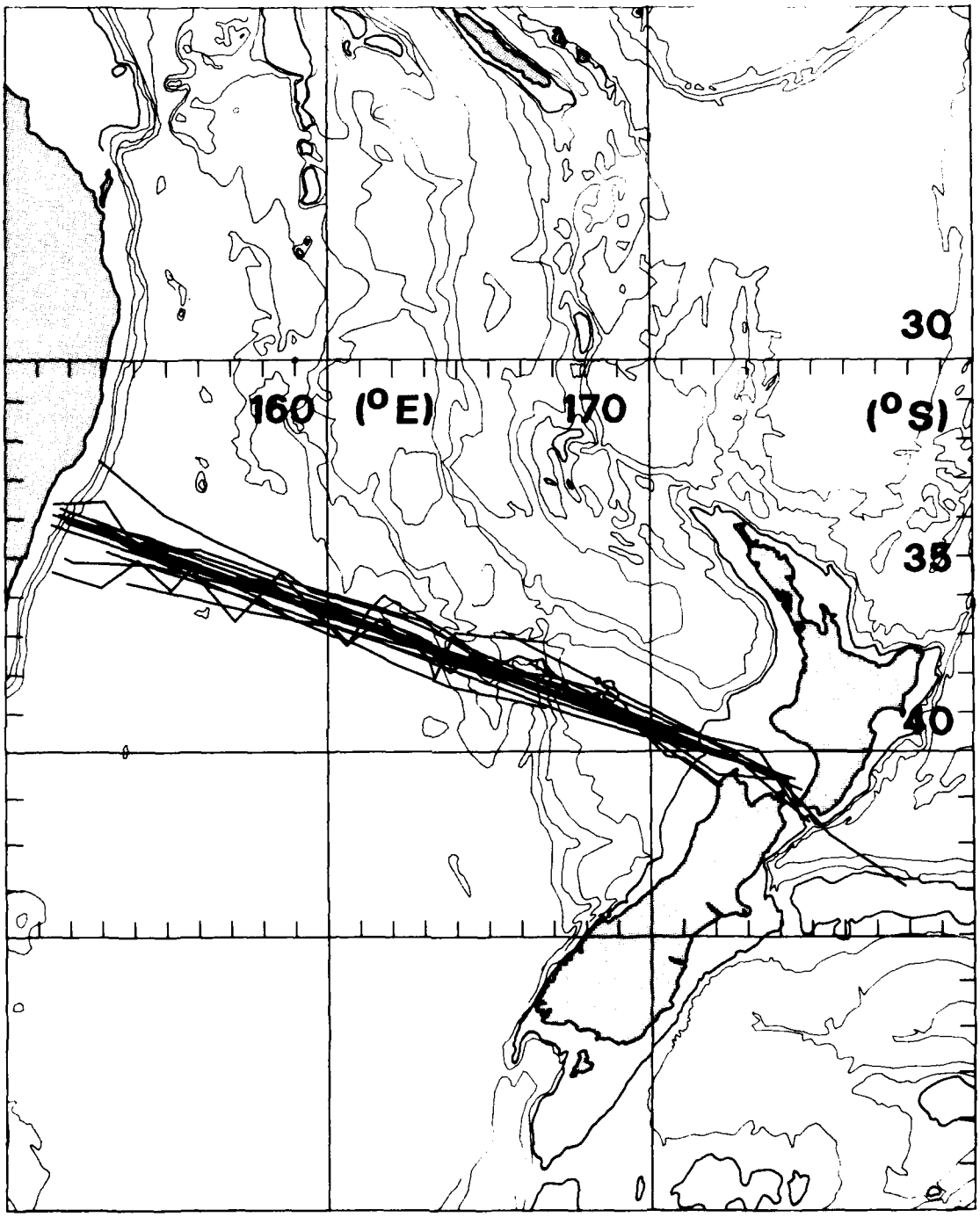

Figure 5: Overplots of 23 XBT transects from Sydney (34 S, 151 E) to Cook Strait (40 S, 172 E) (route B).

Table 4: *AODC cruise numbers, dates and times for BT sections from Sydney to south of Fiji (and Vanuatu) (39 sections). Overplots of the ship tracks are shown in Figure 6*

Survey	Month	Year
42789	12	1971
42794	10	1971
43398	08-11	1972
43401	10-11	1972
43962	08	1972
44543	07	1972
44598	11	1968
45177	09-10	1973
45311	07-08	1974
45315	10	1974
45814	02	1975
46718	04	1973
48929	11-12	1971
50094	04-06	1975
50273	09	1975
50744	05-08	1976
50745	05-08	1976
50745	08	1976
50753	02 03	1976
60042	11	1978
60070	06	1979
60079	01-04	1980
60164	10-11	1981
60346	12	1981
60375	05-08	1985
65951	05	1981
65957	05	1982
65961	03	1982
65969	10-11	1982
65988	04	1983
66154	05	1984
66164	05-06	1984
66176	04-05	1985
68240	04-05	1986
68267	05	1986
68399	10	1971
SEAMAP 2	07	1985
SEAMAP 3	03	1986
SEAMAP 6	09	1987

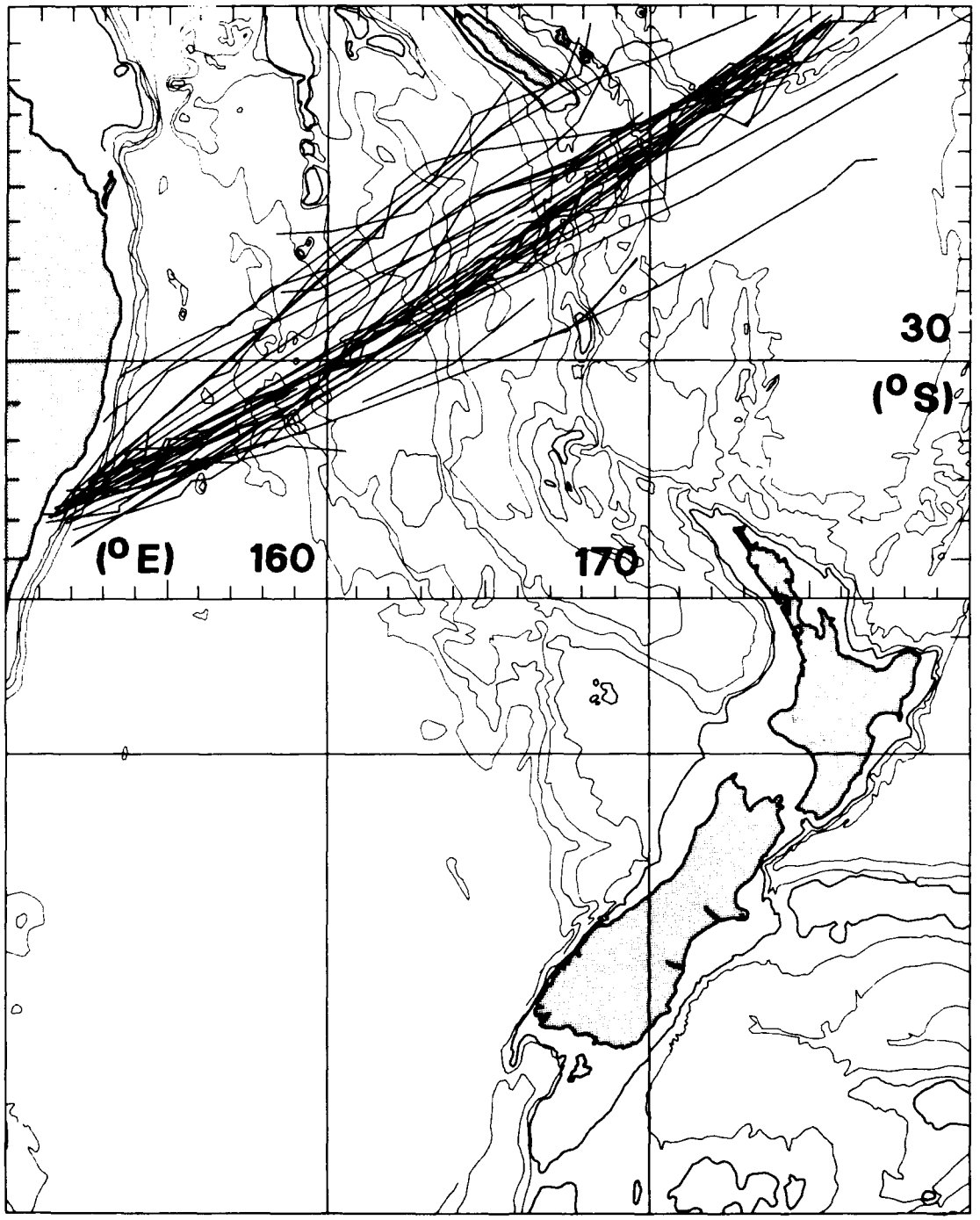

Figure 6: Overplots of 39 BT transects from Sydney (34 S, 151 E) to south of Fiji (route C). Fiji is located at 18 S, 178 E.

Table 5: AODC cruise numbers, dates and times for BT sections from Central Queensland to north New Zealand (12 sections). Overplots of the ship tracks are shown in Figure 7. See Denham and Crook [5] for a discussion of some of these sections.

Survey	Month	Year
41018	02	1970
41660	07	1971
41832	10	1971
42409	04	1972
43413	12	1972
43422	09	1972
43320	01	1973
44356	01	1973
44903	11	1973
45177	09-10	1973
48374	11	1973
68388	09-10	1980

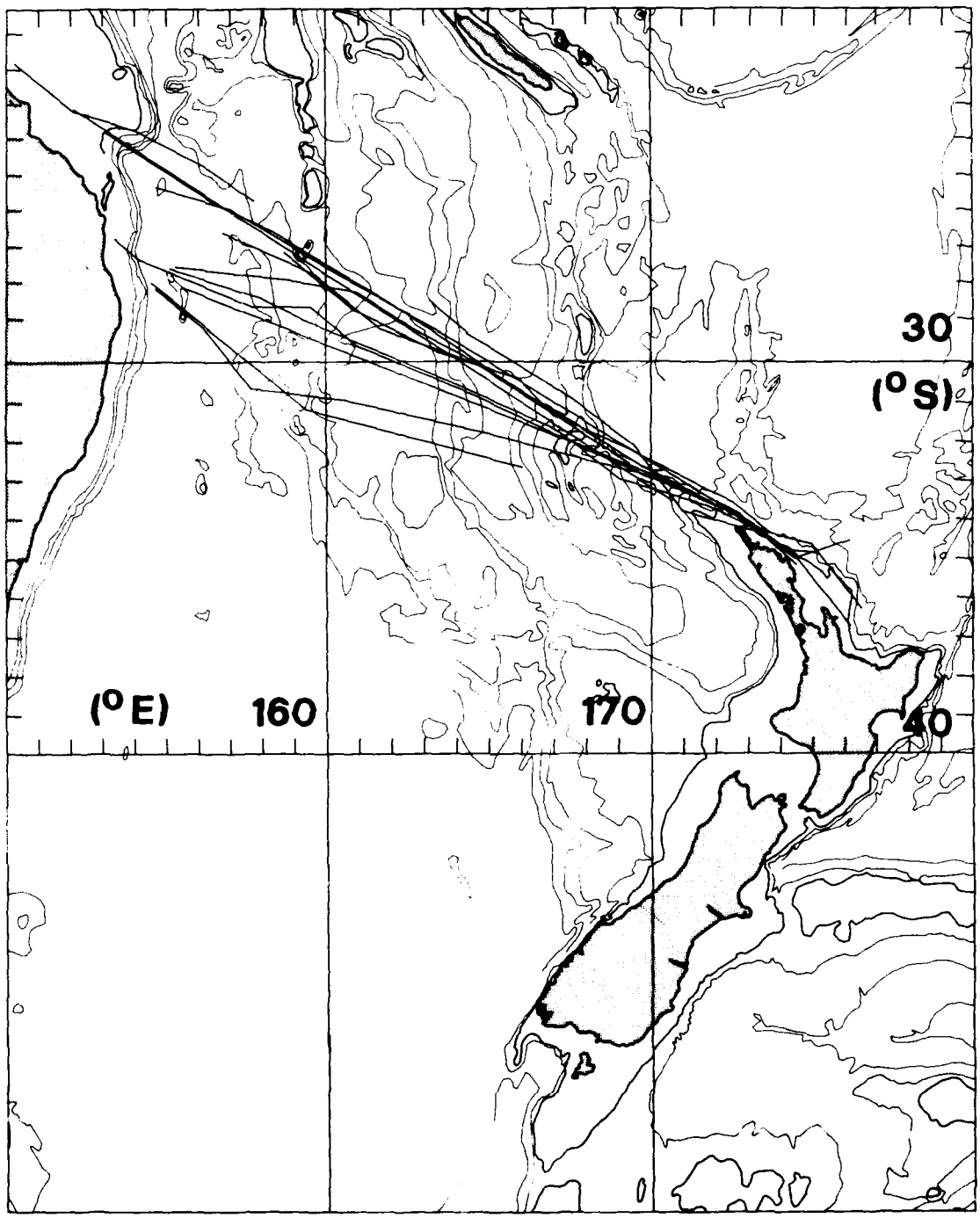

Figure 7: Overplots of 12 BT transects from Central Queensland to north of New Zealand (route D).

Table 6: AODC cruise numbers, dates and times for BT sections from Tasmania to north of New Zealand (8 sections). Overplots of the ship tracks are shown in Figure 8.

Survey	Month	Year	
44800	11	1973	
51318	06-07	1976	
60020	06	1978	
60037	11	1978	
60225	10-12	1982	
65947	10-11	1980	
68396	09-10	1977	
Canberra	02	1990	Constructed from telex data, not from original traces

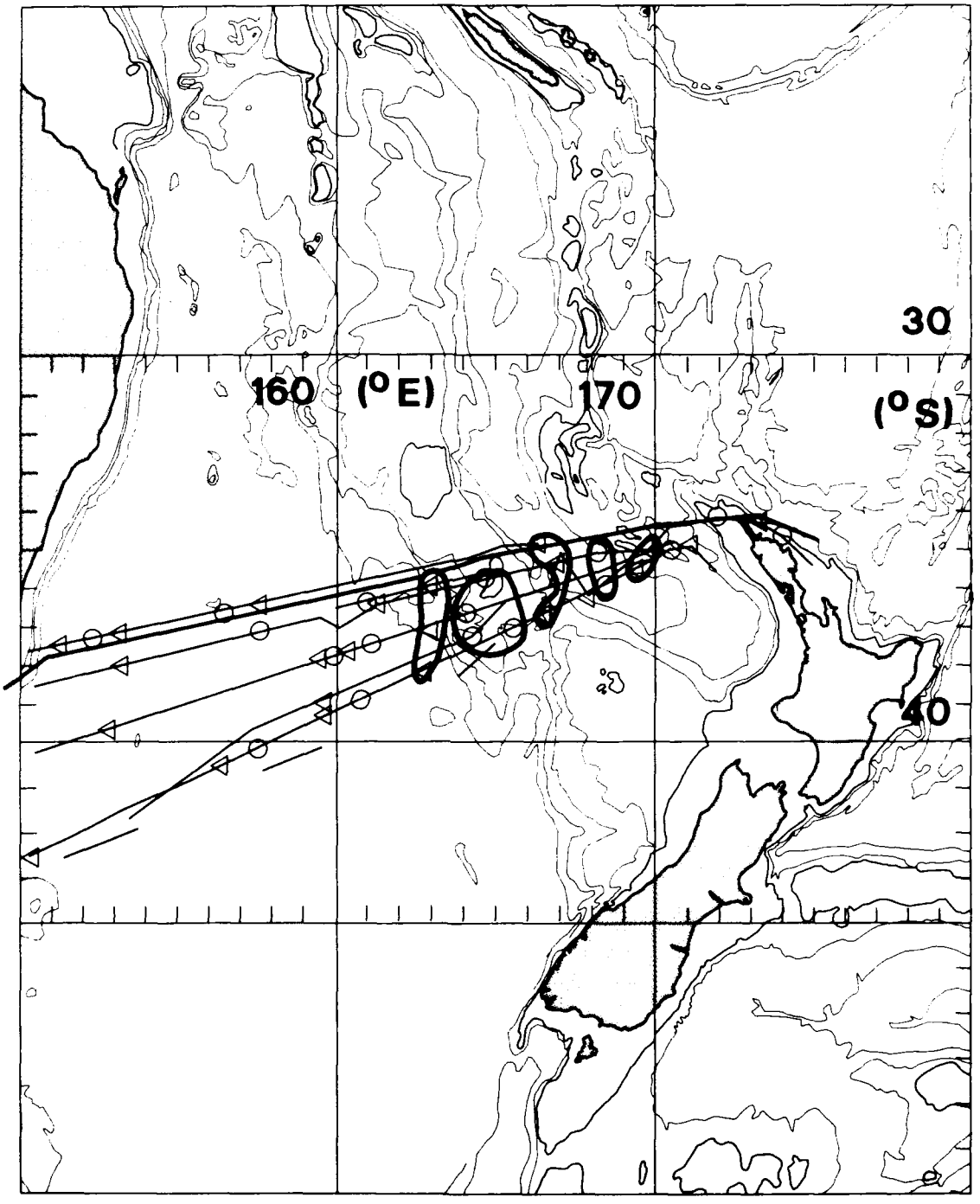

Figure 8: Overplots of 8 XBT transects from Tasmania to north of New Zealand (route E), and positions of axes of warm and cold features. (o - cold axes, triangles - warm axes). Possible groupings of axis types are shown.

Table 7: AODC cruise numbers, dates and times for zonal BT transects from Tasmania to New Zealand (18 sections). Overplots of the ship tracks are shown in Figure 9.

Survey	Month	Year	
Bass Strait to Cook Strait			
21179	11	1966	(MBT)
42464	02-03	1972	
45151	09	1973	
66163	11-12	1984	
SEAMAP 1	02	1984	
Hobart to Cook Strait			
1869	02	1958	(MBT)
6598	01-02	1965	(MBT)
14932	03	1967	(MBT)
41662	04	1971	
48937	03-04	1973	
68383	01-02	1982	
Tasmania to South of New Zealand			
1443	12/56	or 3/57 (?)	(MBT)
2855	02	1959	(MBT)
4209	12	1960 (?)	(MBT)
5221	03	1962	(MBT)
5703	02	1963	(MBT)
49482	01-03	1975	
66177	07-08	1985	

The (?) indicate that the date is uncertain. Sections are for XBT unless shown as MBT.

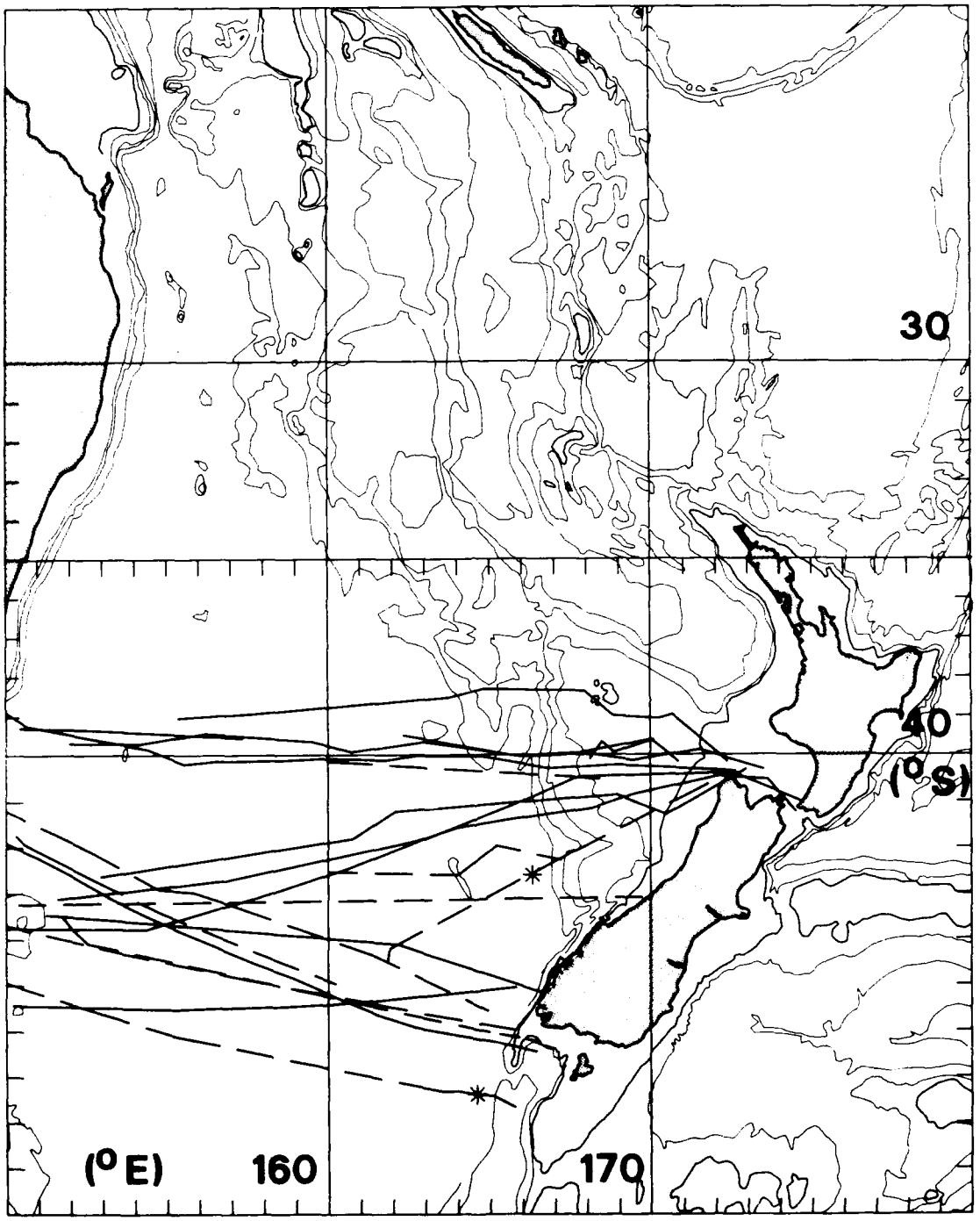

Figure 9: Zonal XBT (----) and MBT (- - -) transects from Tasmania to New Zealand (route F). Asterisks show two strong temperature fronts (2°C temperature change).

Table 8: *AODC cruise numbers, dates and times for miscellaneous BT sections in the Coral/Tasman Seas (over 40 sections) including:*

- *Hobart to south of Fiji (2 sections) : 42970 46067*
- *north New Zealand to south of Fiji (6) : 41832 44796 44800 44800 50753 73545*
  (see Denham et al. [6] for a discussion of these sections)
- *Sydney to north of New Zealand (3) : 5221 SEAMAP 3 SEAMAP 6*
- *Sydney to south of New Zealand (4) : 42091 49482 SEAMAP 1 SEAMAP 2*
- *Southeast of New Zealand (4) : 44780 44780 44796 48937*

Overplots of the ship tracks are shown in Figure 10.

Survey	Month	Year		
5221	04	1962	MBT	Section 5221 was an MBT section
41125	09	1967		
41832	10	1971		
42091	01-02	1972		
42970	02	1971		
44780	12	1973	(?)	The (?) indicates that the date is uncertain
44780	02	1974	(?)	
44796	12	1973		
44796	12	1973		
44798	10	1973		
44798	10	1973		
44800	11	1973		
44800	11	1973		
46067	04	1972		
47301	03	1969		
47301	03	1969		
48929	11-12	1971		
48929	11-12	1971		
48937	03-04	1973		
49482	01-03	1975		
49482	01-03	1975		
49749	10-11	1974		
50294	11	1975		
50320	11-12	1975		
50753	02-03	1976		
60015	03-05	1978		
60053	01-03	1979		
60073	07-09	1979		
60164	10-11	1981		
60208	07-10	1982		
65946	04-05	1978		
65964	05-06	1982		
65980	10	1982		
68243	07	1986		
68384	03-04	1982		
68396	09-10	1977		
70138	06	1986		
73545	04-06	1987	(?)	
SEAMAP 1	01	1984		
SEAMAP 2	07	1985		
SEAMAP 3	03	1986		
SEAMAP 6	07-03	1987		
Canberra	04-05	1990		Constructed from telex data, not from original traces

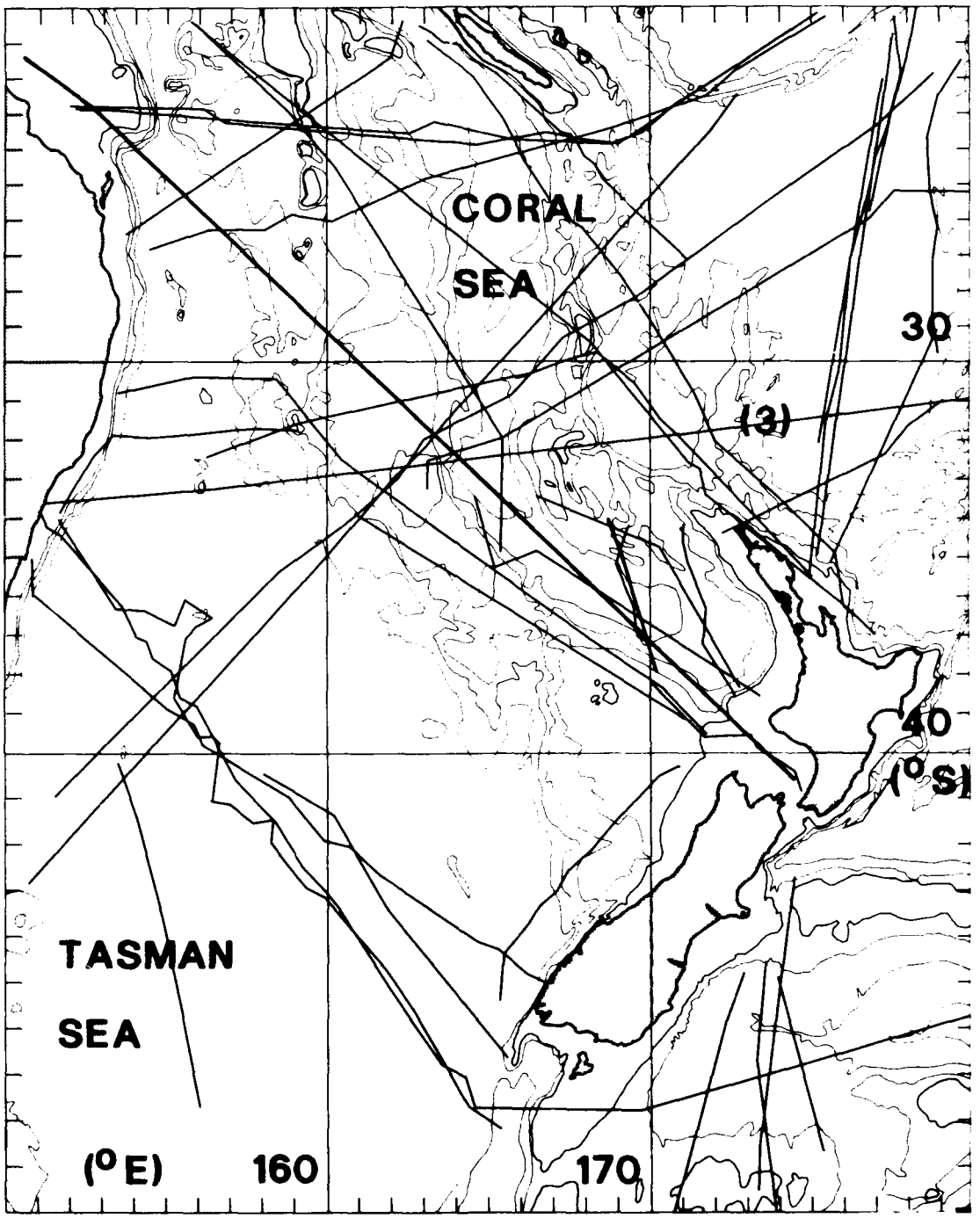

Figure 10: Miscellaneous XBT transects not lying on routes A to F of Figure 1. Of particular interest are two transects from Hobart to south of Fiji, and four from Sydney to south of New Zealand. The (3) indicates three tracks for the transect shown. More tracks southeast of New Zealand are available than are shown. Shorter transects and transects along the Australian coastline are not included.

5. Explanation of Symbols Used on the Ship Tracks and Temperature Sections

Ship Tracks

Ship track is shown as straight line segments joining positions of XBTs used to construct the temperature sections. Occasional dashed extensions to ship tracks indicates that this part of the track deviates from the route and is shown on another microfiche. For example the dashed extension for survey 41125 of route A is shown in the miscellaneous transects.

XBT positions are shown as small crossbars on the tracks, with selected XBT consecutive numbers.

A few diagrams show more than one ship track for an AODC survey number. The ship track diagram is repeated as many times as there are sections, e.g. see the two sections for survey number 43403 on route A.

A sample track is shown in Figure 11.

Temperature Sections

The crosses and positions at the top left and right hand side of each section show the end points of the straight line onto which BT positions were projected to form the section.

The 15°C isotherm is shown as a dashed line on all but a few sections, and is generally not labelled. Selected values are shown for other temperature contours.

Positions of XBTs on the temperature sections are shown by an upturned "V" at 500 m depth, and an asterisk at the surface. However, if the XBT hit bottom, the asterisk is shown at the bottom depth instead. Short traces with wire breaks are sometimes wrongly shown in the AODC data bank as hitting bottom, e.g. see survey 50292 for route A, and survey 41660 for route D.

For the reasons described in the Data and Methods section of the text, contours towards the lower limits of sections are occasionally spurious when BTs attain different depths. This condition can also occur when a BT is much shallower than adjacent BTs.

A sample temperature section is shown in Figure 12.

6. Acknowledgements

Gary Hopwood of the Royal Australian Navy Hydrographic Office, North Sydney supplied the tape of bathy-thermograph data and scatter plots of the data sites from the holdings of the Australian Oceanographic Data Centre. Peter Tate (then of Ocean Sciences Institute, University of Sydney) provided a FORTRAN programme to generate Mercator projections.

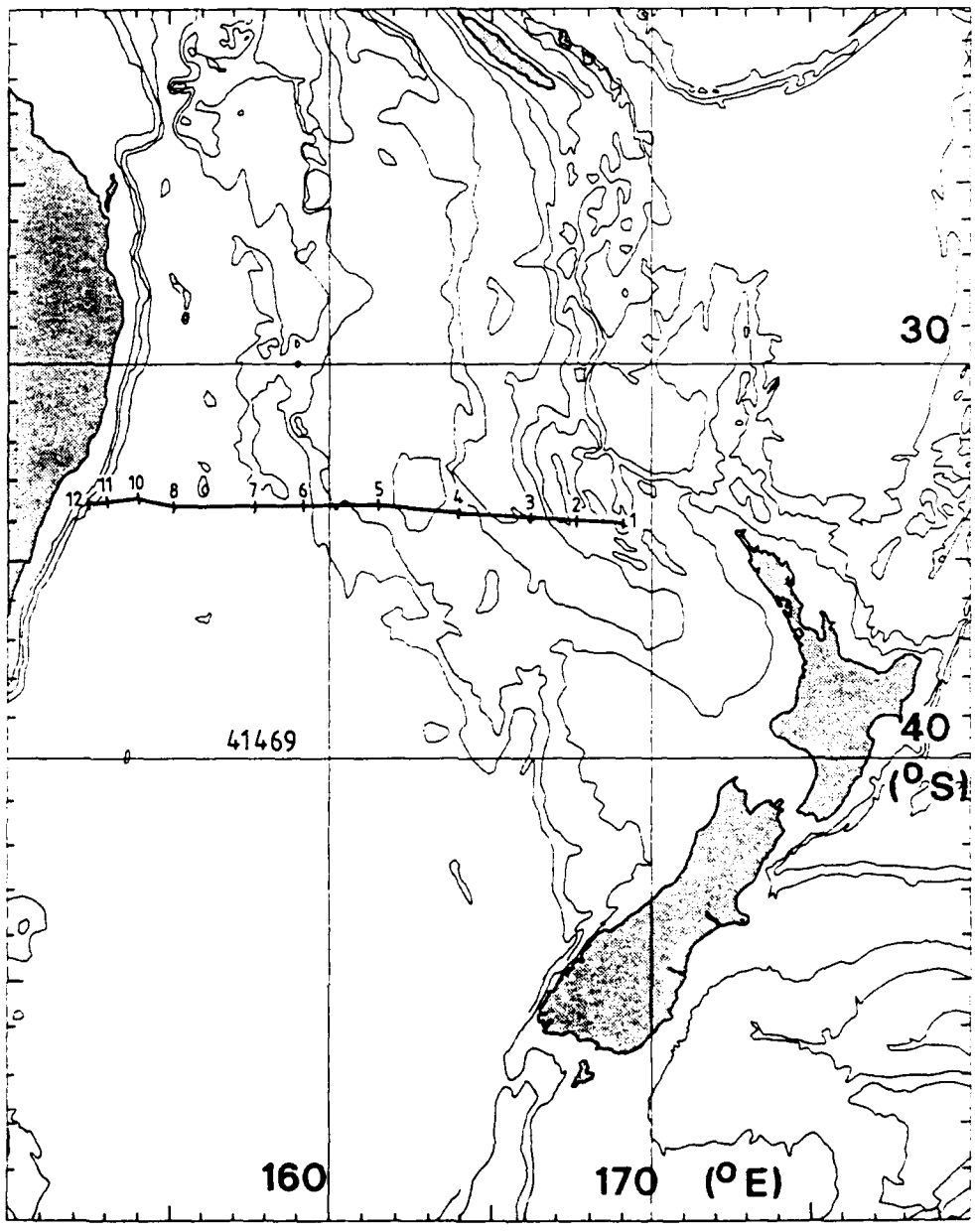

Figure 11: Sample of snip track.

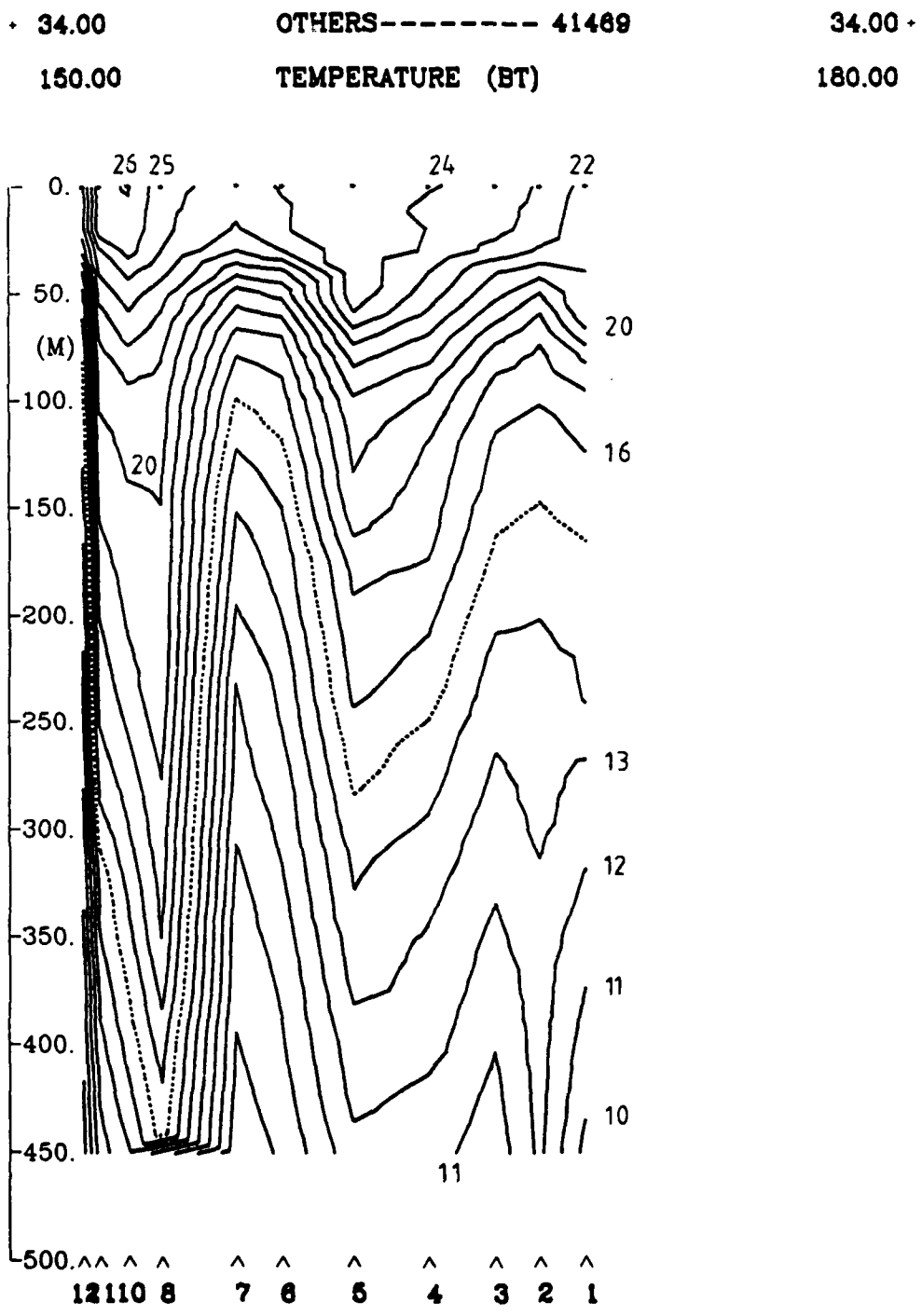

Figure 12: Sample of temperature section.

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An atlas of bathy-thermograph temperature cross-sections for Coral and Tasman Sea transects from 1960 to 1987

AUTHOR(S)
L.J. Hamilton

CORPORATE AUTHOR
DSTO Materials Research Laboratory
PO Box 50
Ascot Vale Victoria 3032

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ABSTRACT

An atlas of 190 temperature cross-sections is presented for the Tasman and Coral Seas for 1960 to 1987. The sections were constructed from bathy-thermograph (BT) temperature profiles obtained by ships on routes between Australia, New Zealand and Fiji in the region 20-50 S, 150-180 E. About 150 sections lie on six major routes, e.g. 50 sections are available from Sydney to New Zealand along 34 S, and 40 sections from Sydney to Fiji. Depth of sections is nominally 450 m. The sections provide the background for an examination of Tasman and Coral Sea surface flow and temperature structure presented elsewhere. Data were obtained from the Australian Oceanographic Data Centre.

An Atlas of Bathy-Thermographic Temperature Cross-Sections for Coral and Tasman Sea Transects from 1960 to 1987

L.J. Hamilton

(MRL-TN-620)

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